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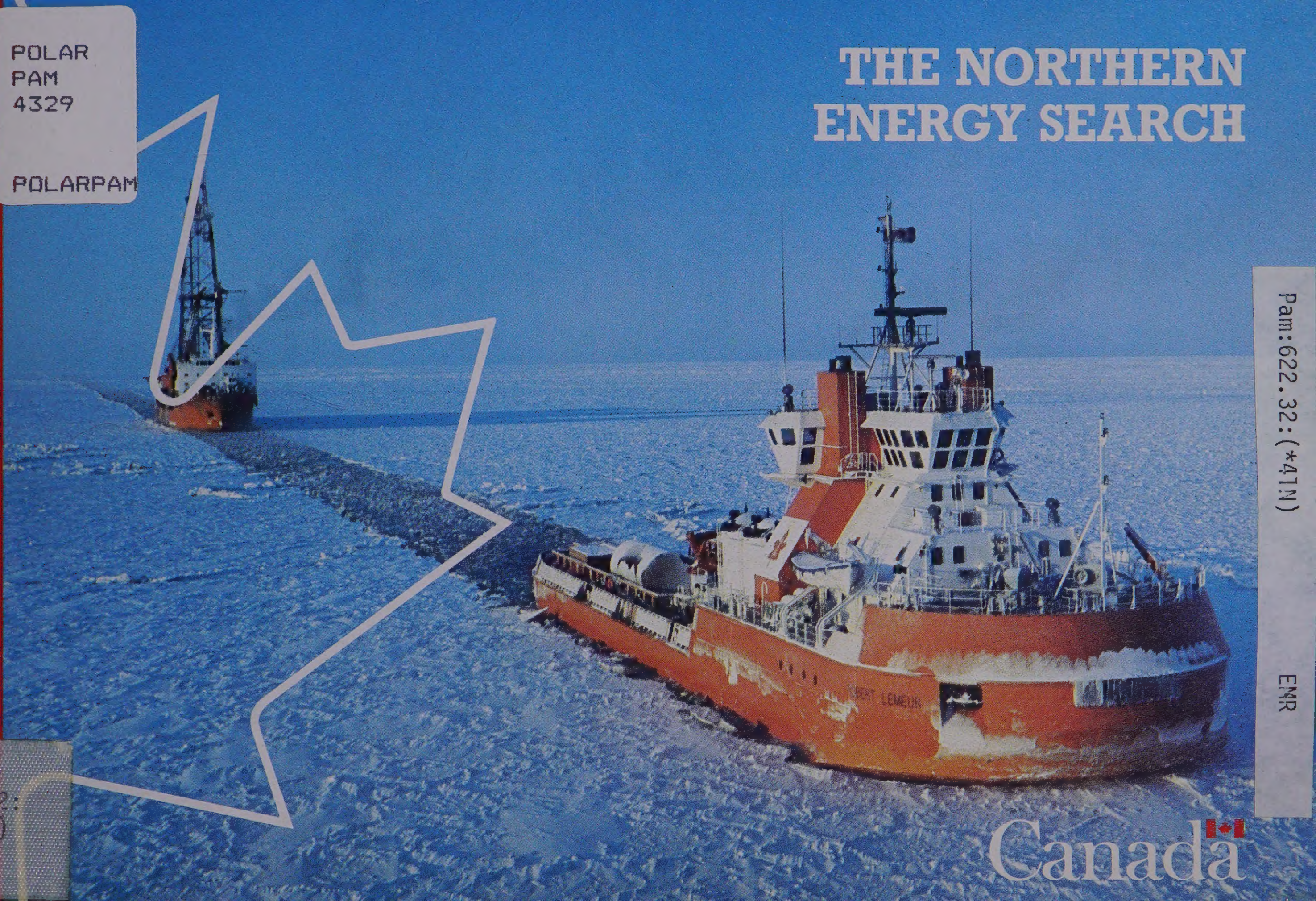
THE NORTHERN ENERGY SEARCH



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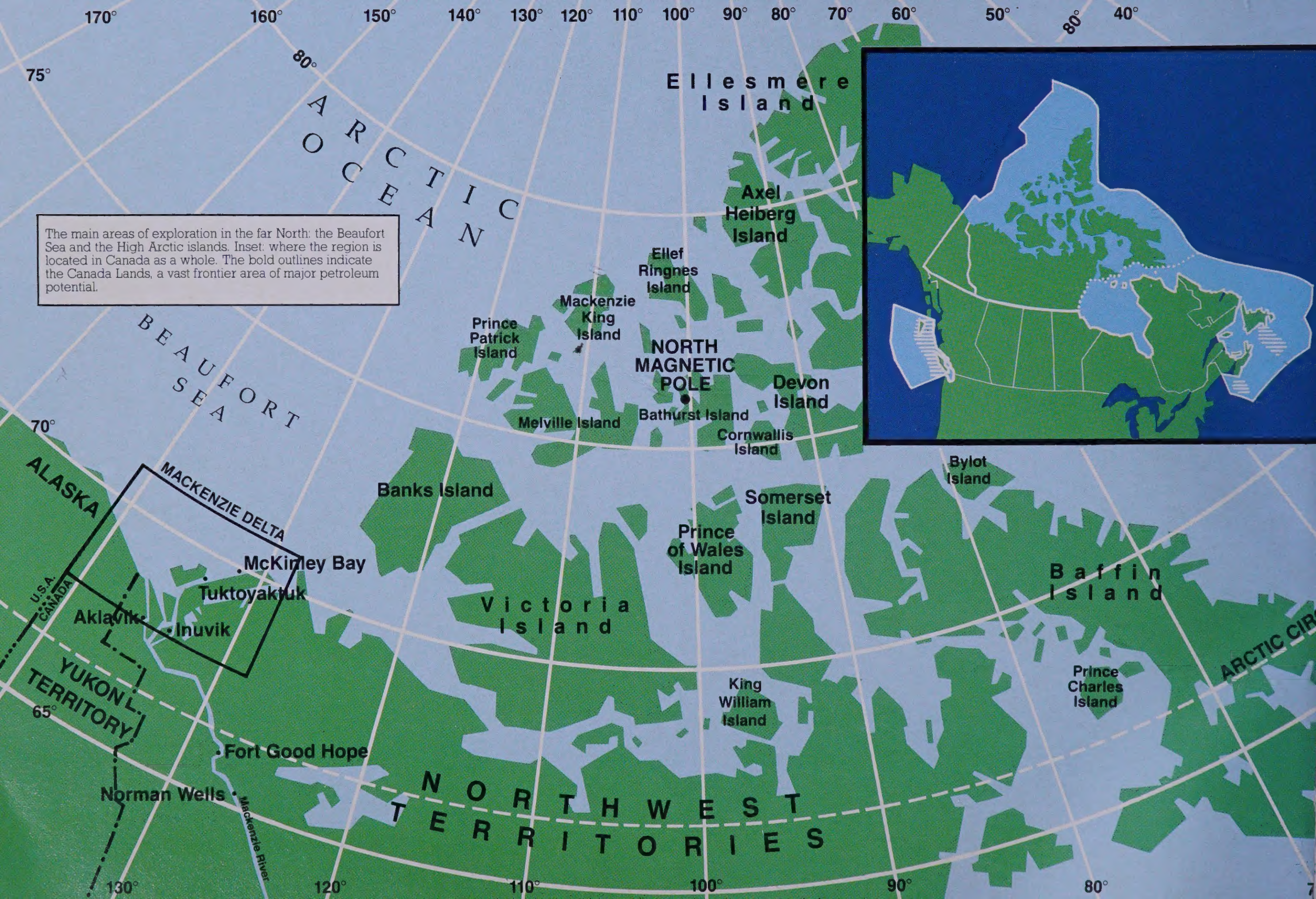

The main areas of exploration in the far North: the Beaufort Sea and the High Arctic islands. Inset: where the region is located in Canada as a whole. The bold outlines indicate the Canada Lands, a vast frontier area of major petroleum potential.

Imagine yourself in the dead of winter, working in a frozen snow field that reaches to infinity in all directions. The extreme cold—perhaps minus 75 degrees Celsius th the wind chill—burns your body ergy at three times the normal rate. ily bundled layers of clothing prevent ur flesh from freezing in less than a nute. The only sounds are the unding rhythms of modern machinery, d in the intermittent moments when machinery stops, there is a profound d alien silence. You could be, if you agine long enough, on the far side of moon.

This is no science fiction fantasy. It's a ene repeated day after day by rkers and explorers searching for roleum in Canada's immense thland, far above the Arctic Circle. ne of the most promising petroleum ential in the world could be in this ion, which stretches for at least 2500 ometres from the Mackenzie Delta l the Beaufort Sea northward into the hipelago of the Canadian High Arctic.

Footprints symbolize the human activity in the vast, uninhabited regions of the Canadian North.
Photo: Dome Petroleum Ltd.

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A furious Arctic storm takes on the qualities of the surreal.

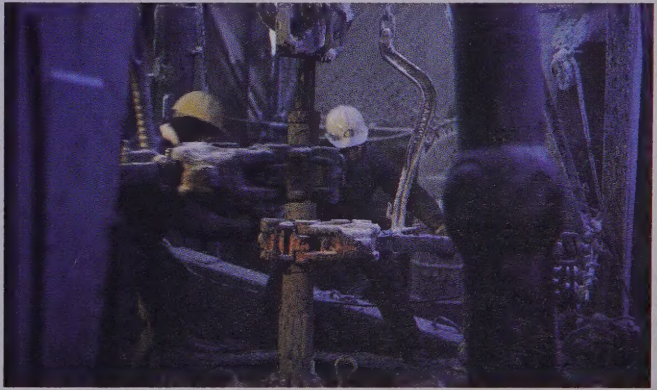
Shifting, bulging (and dangerous) ice surrounds an artificial island in the Beaufort Sea.
Photo: Imperial Oil Ltd.

To survive on a Northern drillsite, there is almost no such thing as overdressing.
Photo: Panarctic Oils Ltd.

This is part of the northern rim of the world, edging ward the North Pole itself. It is, at once, both starkly autiful and hostile. For at least eight months of the year, mperatures remain below freezing. In February, the ldest month, routine temperatures are minus 35 degrees lsius, and the effect is often double that when combined th the wind. There is no daylight for upwards of four nths of the year. Ice is everywhere: thick, shifting ice so midable it can crush a sturdy ship like a tin can. Arctic rms, carrying rain and spray that freeze on contact, oop in without warning. Everything in their path is coated th ice. Even farther south, small ships have been known capsize from the weight of ice forming suddenly on their perstructures. Where drilling takes place, the teams rk, eat, sleep and spend their leisure hours within the twork of buildings surrounding the drill rig or below ck on their drillship. Most of them work 14 consecutive -hour days, spend 14 days off in the South, and return for t another round of 14 work days.

In an employee handbook issued by one oil company rking in the North, a somber warning sums up the nditions of this region: "If you fall into the water, your dy cannot produce enough energy to swim and keep the art beating; therefore, do not swim; keep calm, conserve ergy by assuming the fetal position until rescue takes ace."

Strange Arctic mammal? It's actually the newest thing in Arctic fashion — all the better to battle the fierce wind and cold. *Photo: Esso Resources Canada Ltd.*



Workers on a frigid Northern drilling platform vividly demonstrate the difficulty of their job. *Photo: Imperial Oil Ltd.*

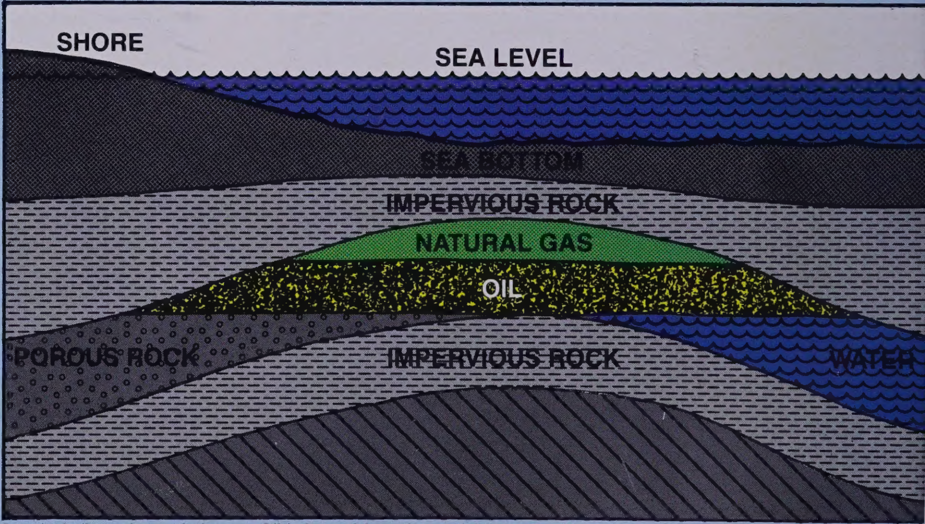
The Origins of Oil

It is widely accepted today that petroleum originates from the remains of once-living organisms. This theory is largely supported by the fact that the world's largest oil deposits have been found under land that once was covered by ancient seas (the Arabian sands), or in the shallows of existing seas (such as the Gulf of Mexico).

Hence, the search for energy in recent years, as oil has become more and more scarce, has moved from the inshore shallow waters to the continental shelves and deeper seas of the world, and into increasingly forbidding environments such as the Beaufort Sea and the Arctic Ocean.

These once-living organisms contained hydrogen and carbon, the basic elements of crude oil and natural gas. Over many millions of years, the combination of heat from the earth's core, and the enormous pressure exerted by the continuous accumulation of sediment, wrought great chemical changes to this layer of once-living matter. What were once a lot of dead plants and tiny animals became petroleum hydrocarbons.

As the earth's crust shifted and heaved, the petroleum—trapped beneath layers of rock—squeezed between the strata and moved, usually upwards. Much of it made its way to the surface and was lost, but some remained underground, caught in porous sandstone or other reservoirs, and was trapped beneath dense shale or limestone. Held in these natural storage tanks under extreme pressure, the hydrocarbons arranged themselves according to density—gas on top, oil beneath and, frequently, water at the bottom.



A typical oil trap beneath the sea. Oil is formed from the partial decomposition of organic matter. After millions of years, the oil migrates through sedimentary rock until it reaches a place where it becomes trapped. Drilling releases it.

e Challenge

eum exploration and production in rth present special problems that known in conventional petroleum y. There is the climate, perhaps rshest in the world; there are the ve (and costly) artificial islands, pecifically to counter unique rn conditions; there are the y reinforced ships used for ration and ice-breaking; and there need for undersea pipelines (yet built) to collect and transport oil as to southern markets.

costs of commercial petroleum ery in the North can be up to 10 higher than those of the South. To ughnecks, workers and scientists drilling platforms in the Beaufort e High Arctic, drilling a single ay seem like drilling 50 ntional ones in the South.

A well in Alberta yielding total reserves of about 48 000 cubic metres (300 000 barrels) would be considered economic on its own. In the North, a typical field would require reserves of about 80 million cubic metres (up to 500 million barrels) before the oil accumulation could be considered a commercially viable discovery.

Despite the costs and the many obstacles, the search for northern petroleum is vital if Canada is to find out just how much petroleum there really is in the region.

The Geological Survey of Canada in 1982 estimated the average expectation of petroleum potential in the Mackenzie Delta - Beaufort Sea region to be roughly 1.5 billion cubic metres (9.4 billion barrels) of oil, and 3.2 trillion cubic metres (113 trillion cubic feet) of natural gas. In the High Arctic, there is an average expectation of 683 million cubic metres (4.3 billion barrels) of oil, and 2.5 trillion cubic metres (88 trillion cubic feet) of natural gas. Taken together, these estimates far exceed all remaining proven, conventional, light oil and gas reserves in Canada.

At the moment, Canadians depend on petroleum for at least 65 per cent of their energy needs. Our commitment is to achieve oil self-sufficiency by the end of the 1980s, but it won't be easy—or cheap. In addition to finding more oil and gas in western Canada, we must extend our search to the distant frontiers of the North and the East Coast offshore. We must be able to extract our resources when they are needed.

The Busy Beaufort

Much of the energy exploration in Canada's North is taking place in the Beaufort Sea and the Mackenzie Delta region.

Drilling in the offshore Beaufort began in 1972, but exploration in the Mackenzie Delta goes back to the early 1960s.

From 1972 to the end of 1982, a total of 38 wells had been drilled offshore in the Beaufort Sea—22 from man-made islands in shallow waters and 16 from conventional drillships in deeper waters. This activity has resulted in numerous oil and gas discoveries at such locations as *Kopanoar, Issungnak* and *Tarsiut*—Inuit names given these offshore drilling sites.

Dome Petroleum has drilled in water up to 67 metres deep in the Beaufort Sea. The company operates 100 to 150 kilometres offshore in the July-October open-water season. During this period, which may be as short as 100 days, up to 1000 workers are employed.

In summer, the Beaufort is plagued by cloud and fog—fog so dense that helicopter pilots are often unable to shuttle between base camps in

The busy port of Tuktoyaktuk in the Mackenzie Delta serves as base camp for petroleum companies working in the Beaufort Sea. In the background is the Beaufort itself.

yaktuk and the various drilling sites
Beaufort Sea. The fog also makes
ost impossible to fly ice
naissance missions.

winter, when the the Beaufort Sea
ozen over, the formation of fog is
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eeze-up in the Beaufort begins in
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new ice forms in the early winter, it
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s of the Beaufort. At the same time,
elentless polar ice cap expands
ward, and the two ice fronts close
ch other. The moving floes of the
pack grind against the
bilized landfast ice that has
nded northward from the coast.
area is known as the *shear zone.*

Drillships in silhouette in the Beaufort Sea.

Sizing up with Seismic

The responsibility for choosing a particular drilling point in the North is more than a little intimidating. To spend many millions of dollars constructing an artificial island with no guarantee of success requires a concerted effort to minimize the very large risks.

Oil companies couple modern technology with an ever increasing geological awareness. The use of sophisticated seismic surveying equipment allows energy prospectors to study the structure of the subsurface and spot potential pockets of petroleum. But these pockets (or "traps") may hold uneconomic quantities of oil or gas and may even contain nothing more than water.

Drilling profitably requires more than just a few shreds of information. It requires a comprehensive understanding of the local geology. The Institute of Sedimentary and Petroleum Geology (ISPG) in Calgary helps provide this necessary overview.

A seismic work crew in the High Arctic. The machinery drills holes in the ice for the placement of explosive charges, whose shock waves probe the sedimentary layers far below the seafloor. *Photo: Panarctic Oils Ltd.*

Established in 1967 as a division of the eological Survey of Canada (which in rn is part of Energy, Mines and esources Canada), the ISPG helps the nergy explorers in three important ays. First, it serves as a repository for ttings and drill core samples on behalf the regulatory agency, the Canada Oil d Gas Lands Administration (COGLA). econd, it operates as a clearing house r the masses of geological data enerated by the various oil companies work in western, northern and fshore Atlantic Canada. Finally, the ISPG scientists carry out geological studies of northern areas, which in turn lead the way to the exploration activities of the industry in these regions.

Drill cores and cutting samples from all exploratory wells drilled in the Yukon and Northwest Territories (including the Arctic Islands, Baffin Bay and Davis Strait), are catalogued and stored in the ISPG. More than 21 000 boxes of cores and nearly 11 million cutting samples are housed here and are made available to industry, the general public, government and the scientific community.

Raymond Thorsteinsson, ISPG's Senior Research Scientist and perhaps Canada's greatest Arctic geologist, frequently visits the North to conduct field operations. His fieldwork takes several years to complete, and results in a greater understanding of the chronological order in which the various layers or strata of the earth were laid down. Reconnaissance geology involves the study of fossils and bedrock mapping, the examination of glacial deposits and, of course, the evaluation of the economic geological potential of the area.

It is the work performed by the ISPG in the Arctic Islands and in the Mackenzie Delta that has attracted the attention of the modern explorers. The data, the published maps and the samples created by the drilling activity to date have all contributed to the great increase in oil exploration in these regions. In short, the work of the ISPG has led many people to believe that the northern and Arctic regions will likely contain a considerable part of the energy resources yet to be found in Canada.

The Players

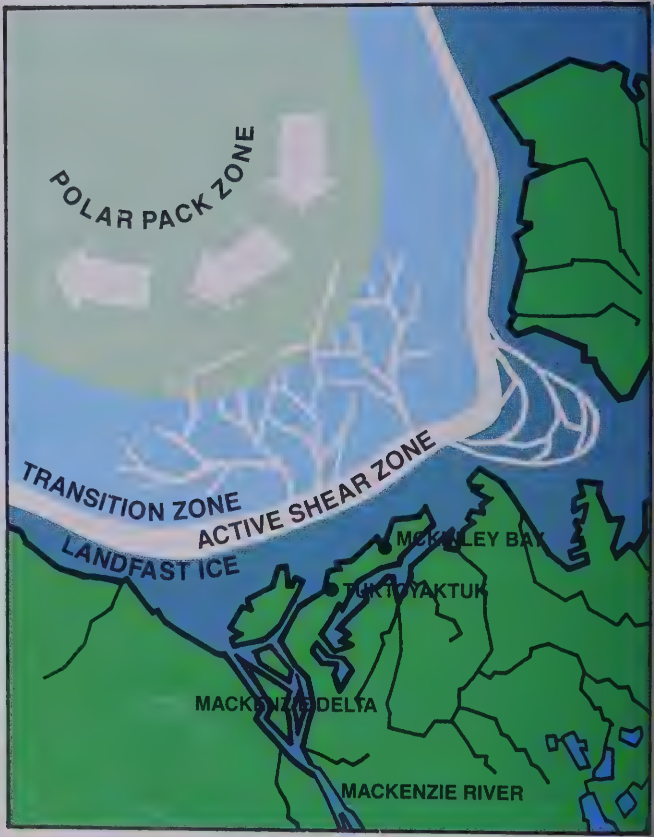
The search for petroleum is part geology, part geography and part adventure. It's also a game of chance. Oil exploration companies must approach difficult and risky problems using a variety of the latest technological systems.

Dome Petroleum, Gulf Canada Resources, Panarctic Oils and Esso Resources Canada are among the major oil companies working in Canada's North, and each has developed its own particular method of operating.

In addition to the four key "players," other major companies participate financially, including Petro-Canada and the Arctic Islands Exploration Group (AIEG), a consortium of companies (Panarctic, Petro-Canada, Gulf and Esso).

The major "plays" in the northern offshore fall into three distinct zones: (1) the on-shore Mackenzie Delta area and the waters closest to the shore, called the *landfast zone*, where the Beaufort Sea thaws during the brief summer; (2) the area further out from shore, called the *shear zone*, where in winter the slowly rotating permanent polar ice pack grinds against the landfast seasonal ice; and (3) the *High Arctic*, consisting of the land and waters north of the 75th parallel, where the ice that covers the inter-island waters, while not always solid, is virtually constant. It is frozen tight in the winter and breaks into a jumble of jostling ice floes in the summer.

Of the four major explorers, Panarctic is the only operator drilling in the Canadian Arctic Islands. Esso has permits for oil and gas exploration close to shore, in the *landfast zone* off the Mackenzie Delta. Dome's permits are mainly in the *shear zone* of the Beaufort Sea, while Gulf's permits are partly in the *shear zone* and partly in the *landfast zone*.



The seasonal pattern of ice shifts and movements in the Beaufort Sea are expressed in so-called "zones."

he Landfast Zone

ere it not for the ice, the Beaufort Sea uld be an ideal environment for the ne-honoured pier technique of drilling shore. At the turn of the century, troleum prospectors drilled off the ds of piers in the shallows of the spian Sea and the Gulf of Mexico. nis technique is still employed in the spian Sea. The piers have grown as ng as 150 kilometres and include rkers' housing along their length—an traordinary evolution of an idea but e well suited only to a temperate vironment.)

Drilling in ice-infested waters is an tirely different matter. In the Beaufort, e bottom drops away very slowly and e water may be shallow—no more than metres deep even when one is out of ght of land. But ice is a formidable foe, d would crush and sweep away the ongest pier.

Imperial Oil has been active in the ackenzie Delta - Beaufort Sea region nce 1964. Through its wholly-owned bsidiary, Esso Resources Canada, the mpany began seabed drilling in 1972. th all its exploration permits for ters no more than 20 metres deep, Esso developed a technique for building conventional artificial islands capable of withstanding the worst landfast ice conditions.

The first of these conventional artificial islands was built in the Mackenzie Delta in only a few metres of water. Dredged material was packed up to just above sea level, where it could support a conventional drill rig.

In 1976, Esso brought the powerful dredge ship *Beaver Mackenzie* into the North to work on island construction in deeper water. The dredge ship works much like a giant vacuum cleaner. It extends a suction pipe to the seafloor, sucks up sand and pumps it through a long, floating tube to the point where the island is to be formed. A barge, or "dump scow," holds the outlet end of the tube in place until the accumulation of sand breaks the surface. Then a bulldozer and several workmen brought in by helicopter shape the surface of the new artificial island.

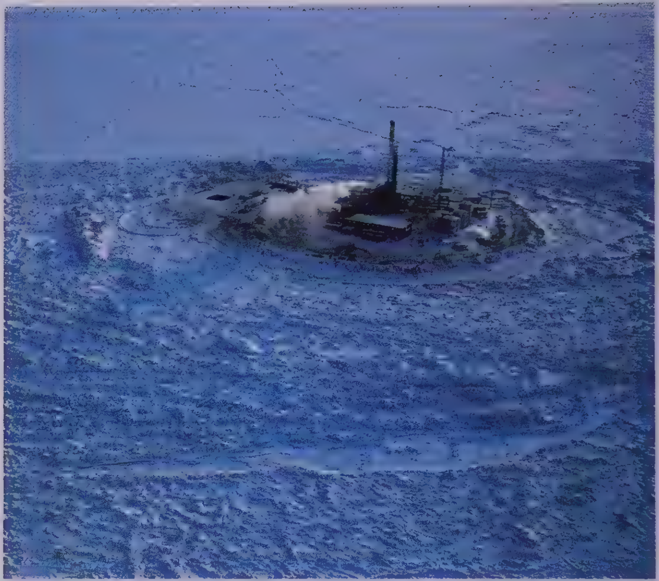
The unique terrain of the Mackenzie Delta features the pingo (centre), an immense core of ice, covered by vegetation, that rises above ground level.
Photo: Imperial Oil Ltd.

The **Beaver Mackenzie** uses its long suction pipes to dredge sand from the seafloor. The sand is used in the construction of artificial islands.
Photo: Imperial Oil Ltd.

Esso has constructed 18 islands to date. Perhaps the best known is *Issungnak* (Inuktitut for "Arctic gull"), which cost roughly $60 million to construct. It was built in 20 metres of water about 80 kilometres northwest of Tuktoyaktuk. The island was composed of 5 million cubic metres of dredged fine sand, and was almost 900 metres in diameter at its seafloor base and 250 metres across at the water line. The crown, or working surface of the island (where the rig and workers' camp are situated), was only 135 metres in diameter. Ringing the crown were many layers of sandbags to protect against waves and erosion energies. More than 14 000 sandbags walled the shores of *Issungnak* when drilling was underway on the island in 1980 and 1981.

In the centre of the island, just 6 metres above the frigid water, a drill rig and accommodation for 72 employees was set up. In the winter months, the artificial islands are surrounded by landfast, immobilized ice. And on this ice formation polar bears wander out to the camp. A 24-hour watch is maintained to guard against these animals.

A hunter stands guard on an artificial island to protect the work crews from polar bears.



Esso Resources' **Itiyok** is a good example of an artificial island that was built entirely of sand dredged from the Beaufort's seafloor. Once exploratory wells are drilled, the islands are abandoned. If production is feasible, the islands can be rebuilt and the wells activated. **Itiyok** was abandoned in mid-1983. *Photo: Imperial Oil Ltd.*

In the summer, supplies can be shuttled to these islands by barge and supply boat through the open water. During winter, helicopters fly through the darkness carrying workers and supplies between island and mainland. Winter ice roads are also used when the ice thickness permits.

Drilling activity at *Issungnak* has been completed for the time being, and the island, to the human eye, has all but disappeared. It has been eroded by ice, and the land is now covered over by the Beaufort Sea waves. If the company decides to bring the wells already drilled into production, the island could be rebuilt.

Esso maintains a small base camp outside Tuktoyaktuk on the mainland. For the workers who fly the helicopters, skipper the boats and oversee operations, this is home. For the men and women who work on the artificial islands, this is only a way-station.

Summer on the Mackenzie River, and a tiny tug propels a barge carrying supplies to Tuktoyaktuk. *Photo: Gulf Canada Resources Inc.*

Workers await transport to drillsite. They have arrived by Dome Petroleum's 737 jet (background). *Photo: Dome Petroleum Ltd.*

Cargo in "cold storage" at McKinley Bay will be used to service and provision the drillships which, in this early spring view, are still immobilized by the landfast ice.

The Shear Zone

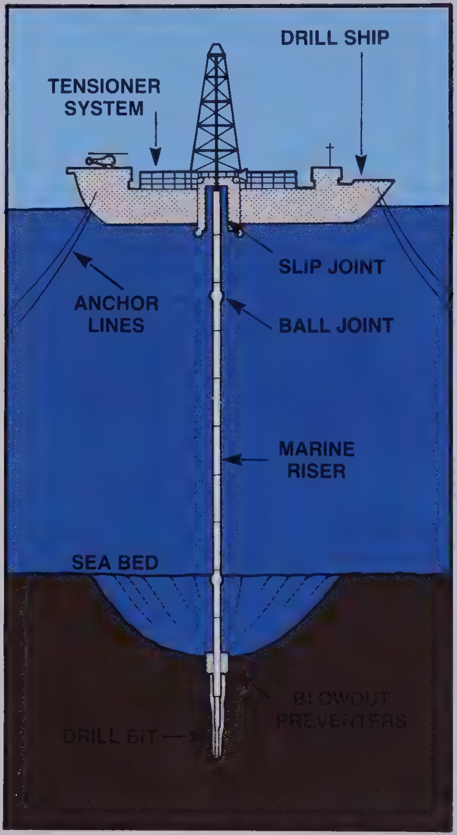
Further offshore, where the waters are 20 to 60 metres deeper, is the 5-to-15-kilometre-wide *shear zone*.

In this area, the seas are never frozen solid, unlike the shallower water inshore. The ice that forms here is constantly shifting throughout the winter by the slowly-rotating, permanent, polar ice pack to the north. In summer, the waters of this *shear zone* open first as the polar pack recedes, but ships can't operate here until they can get through the landfast ice that traps vessels in their harbours.

The winds that bring ice and fog also affect ice conditions. When the wind is from the south, it pushes the pack ice further north, but when the wind swings around to the north, it can blow ice into the drilling areas, causing difficulties.

Dome met this challenge by assembling a fleet of ice-reinforced drillships and support vessels capable of operating in ice. These are operated by Dome's wholly-owned subsidiary, Canadian Marine Drilling Ltd. (Canmar).

A drillship is an unusual craft. A drilling derrick is mounted amidships above a cut-away section of the hull that is open to the sea below. The drillpipe runs down through this "moonpool," as it's called, to the seafloor. Once the ship has arrived at the drill location, which is determined by geologists from seismic data analysis, eight massive anchors—each weighing 14 000 kilograms—are dropped into the sea. Steel cables, as thick as a man's wrist, secure the anchors to the ship so that the vessel, in effect, becomes a floating drilling platform.



This diagram illustrates how a drillship reaches bottom on the open sea.

The ship still responds to ocean swells and wind, and sliding joints, called "marine drilling risers," are incorporated in the drill system to accommodate all the movement. Before drilling begins, a pit, called a "glory hole," is excavated in the sea bed. The wellhead and blow-out prevention stack are set in this seafloor depression. This keeps the wellhead safe from the ice that gouges deeply into the sea bottom during the winter and causes ice ridges.

Despite all these complexities, a drillship has a number of advantages. It can drill in extremely deep water; should an ice floe threaten the vessel, it can disconnect from the well, leaving it temporarily sealed, and move away before any damage can be done; and it can move quickly and easily from drill site to drill site as each well is completed.

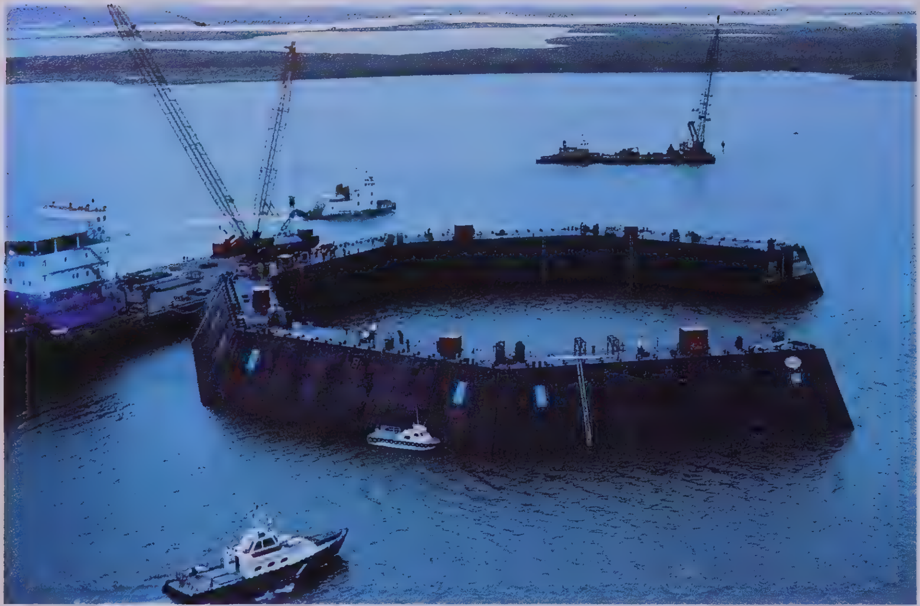
A Dome drillship flares off hydrocarbons during a drillstem test for petroleum at sea.
Photo: Dome Petroleum Ltd.

Dome and its drillships first ventured into the deeper waters of the Beaufort in the summer of 1976. With the assistance of ice-breakers, safe drilling has been conducted amid ice 60 centimetres thick. But the season for open-water drilling is short; the present annual average is 122 days. For the rest of the year, Dome's collection of vessels are at their winter moorings in McKinley Bay, about 110 kilometres northeast of Tuktoyaktuk.

Almost 50 per cent of the Canmar fleet was built in Canada. Canmar owns most of the vessels, but the company also charters some equipment. The fleet includes four ice-reinforced drillships, nine ice-breaker supply boats, two different experimental ice-breakers, a cargo carrier, three dredges and several barges.

In its efforts to drill year round, Dome has begun construction on a new generation of artificial islands. The company's exploration permits are for deeper waters than the acreage held by Esso. The amount of sand required to build a conventional artificial island quadruples with every doubling of water depth, so Dome engineers have set themselves the goal of designing a stable island with a much steeper slope than existing structures.

A flotilla of ships, including icebreakers and supply vessels, works through the breaking Beaufort ice.



Esso's eight-sided "doughnut" caisson-retained island can be unlatched like a necklace and towed to a site, where the centre section is filled with sand and the drill rig assembled on top. *Photo: Imperial Oil Ltd.*

The engineers devised a plan using caisson technology. Floating, pre-cast concrete caissons are sunk (ballasted) into the sea atop a mound of dredged sand called a berm. The berm slopes are set at a much steeper angle than those used on conventional islands, where sand is heaped up enough to break the surface of the sea. Once in place, sand is pumped in behind the concrete walls.

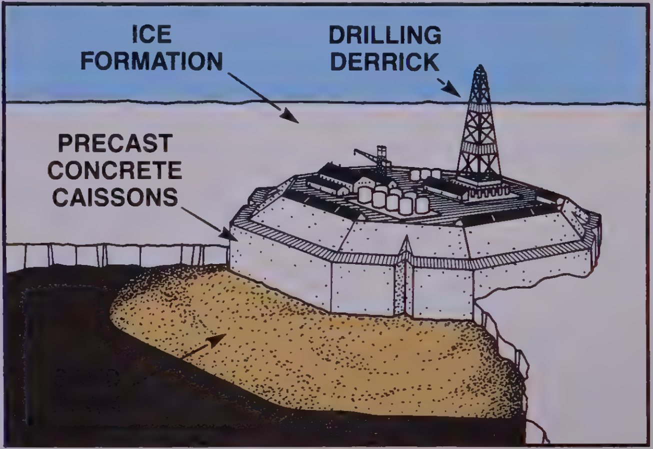
Artificial islands built according to the caisson plan are better protected against erosion by their concrete retaining walls. They also require considerably less sand. A major problem in the Beaufort Sea area is the lack of quality sand to build an island so economizing on sand has become essential.

Dome is a partner in the construction of one artificial island using the caisson technology. Located in 22 metres of water, the island (called *Tarsiut*, Inuktitut for "smal hawk"), is operated by Gulf and cost more than $60 million to construct. It is roughly the same height from seabed to drilling surface as an eight-storey building. While 22 metres of water is only slightly deeper than that in which Esso's *Issungnak* island was contructed, *Tarsiut* is a first step toward eventual year-round drilling in waters as deep as 60 metres.

Dome's single steel drilling caisson (SSDC) is actually two-thirds of a converted tanker that sits on a sand berm. It can be refloated and towed to another drillsite.
Photo: Dome Petroleum Ltd.

Dome has also developed a single, steel-drilling caisson—actually two-thirds of a converted supertanker (minus the stern)—resting on a subsea berm. This structure, which is being used at *Uviluk*, rises about 31 metres from its base to a deck about 80 metres across. Concrete caissons, braced by pumped-in sand, reinforce the tanker walls and provide stability to the overall structure. When the caisson is needed at a new location, the sand will be pumped out and the caisson floated away.

At *Kadluk*, Esso will use a new caisson built of eight steel sections that form a 110-metre-diameter "doughnut." It will be ballasted onto a subsea berm and filled with dredged sand. The caisson sections can also be refloated and relocated.



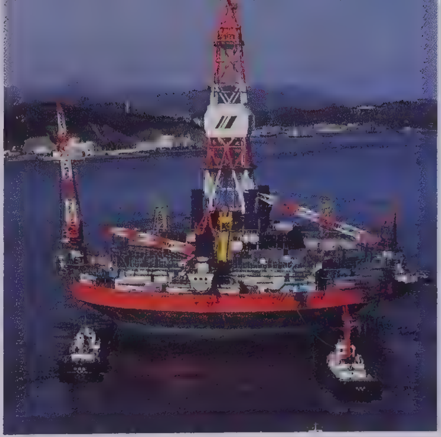
The caisson-retained island is composed of four concrete (or steel) base pieces that rest on a sand berm built up from the seafloor. They differ from the so-called "sacrificial" islands, which are built entirely from sand, and are eventually washed away by the sea. The caisson-retained islands, when disassembled, can be towed from site to site.

Back on the mainland, close to Tuktoyaktuk, Dome's base camp is set up with satellite television, sauna, whirlpool, raquetball court and accommodation for about 700 workers. The company also owns what amounts to a small airline. It includes a Boeing 737 jetliner, four helicopters (and others on contract), a Twin Otter and a King Air.

Since 1975, Gulf has operated in the shallow waters (25 to 50 metres) of the *shear zone*. By 1984, the company will be using two methods of drilling—the conical drilling unit and the mobile Arctic caisson.

The conical unit is a round vessel equipped with a double steel hull, with facilities such as a heliport, fuel storage area, crew accommodations, a galley, food lockers, dining space, laundry, and recreational areas. There is accommodation for 80 to 100 personnel. The conical unit is perhaps better described as an ice-breaker drilling platform, and is the first such unit in the world.

Gulf plans to have the unit operational by the summer of 1983. It is built of 18 000 tonnes of low-temperature steel, and will probably double the drilling season in the Beaufort to at least six months.



Gulfs conical drilling unit is a new breed of drilling platform. Because it remains afloat, and is stabilized by a series of giant anchors, it has no need for a sand berm foundation. *Photo: Gulf Canada Resources Inc.*

Gulfs huge Mobile Arctic Caisson, which will be working in the Beaufort in 1984, is towed to a drillsite and placed on a pre-built sand berm. The drilling derrick is added later. *Photo: Gulf Canada Resources Inc.*

Gulfs other approach to Beaufort drilling is to use its huge mobile Arctic caisson. About the size of two football fields placed side by side, this system will be available in the summer of 1984. The caisson comes equipped with a pre-built drilling rig, supporting equipment and crew's quarters, and the structure is towed—intact—to the drilling site. Giant concrete supports (the caisson "legs"), are sunk to the seafloor, and the space between the supports is filled with dredged material to add stability to the structure.

The new Gulf caisson will greatly reduce the volume of dredged material (sand) used in the fixing of artificial islands at drill sites. This means less expense and less environmental impact caused by seafloor disruption.

Both the conical drill unit and the mobile caisson will be provided with clearance support by two ice-breakers, each close to 100 metres long.

The Gulf activities in the Beaufort Sea in 1982 were centred at *Tarsiut*, although there are indications (based on company testing in late 1982), that the field may contain less oil than first expected. *Tarsiut* is a shallow water site, and recoverable petroleum is no more than about 2000 metres below the seafloor.

Life Without Petroleum

There could be enough petroleum in the North to last us well into the 21st century. And petroleum is a fundamental part of our daily life; without it, modern living would be dramatically altered.

Petroleum means oil, gas and their derivatives and byproducts. Almost everything we do in some way relates to a need for petroleum. It fuels our cars, trucks, farm vehicles, airplanes, ships and trains. Petroleum byproducts are essential in the building of roads and are the necessary ingredients in paints, detergents, plastics, rubber, solvents, synthetic fibres, household appliances and scores of other everyday products we have long taken for granted. Petroleum products are even used in the manufacturing of computers.

Fuel oil provides heat and electricity for many of our homes, offices and manufacturing plants. Natural gas is fast becoming the alternative to conventional heating sources for domestic, business and industrial use.

The Government of Canada has established an important goal of conserving the limited supplies of oil. By 1990, the goal is to reduce the use of oil to 10 per cent of the energy consumed in every sector of Canadian society except transportation. The North may provide Canadians with more oil, but this valuable energy source will not be squandered needlessly.

Breaking the Ice Barrier

Along with other companies working in the North, Dome Petroleum is continually seeking ways to lengthen its drilling season. In 1981, the company constructed a 12.7 megawatts (17 000 horsepower) Arctic Class 3 ice-breaker named *Kigoriak*, the Inuktitut word for "northern lights." As a rough rule of thumb, the Arctic class rating of a vessel is generally equal to the thickness of level ice (in feet) that the vessel can cut through without slowing.

The *Kigoriak* is an innovative hybrid that has shown remarkable ice breaking ability in the ice conditions of the Beaufort—even beyond Class 4 requirements. On occasion the *Kigoriak* has rammed through ice more than 2 metres thick.

In the latter part of 1982, Dome introduced a new ice-breaker to its Beaufort Sea operations. Named the *Father Robert LeMeur* after the first Canadian missionary to inhabit the Far North, the 10.5 megawatt (14 000 horsepower), Class 4 ship was built in British Columbia, is 79 metres long and 16.6 metres wide, and has a maximum cargo capacity of 1400 tonnes.

Ice-breaking tankers would essentially be scaled-up versions of ships like the *Kigoriak*. They are being proposed for transporting petroleum through the Northwest Passage. The ships, according to current plans and proposals, would be extremely powerful. They are expected to be equipped with propulsion systems of at least 112 megawatts (150 000 horsepower) — sufficient to move the craft at up to 33 kilometres per hour (18 knots) in open water and at up to 11 kilometres per hour (6 knots) in ice 3 metres thick.

Such tankers would be double-hulled on their sides and bottom; they would be more than 330 metres long and have a capacity of approximately 200 000 tonnes. Their capacity, per trip, would be almost 240 000 cubic metres (1.5 million barrels). To reduce the risk of a spill the crude oil would be carried only in the centre tanks.

Dome estimates that an ice-breaking tanker could negotiate the roughly 13 000-kilometre round trip between the Beaufort Sea and East Coast markets 16 times a year.

The **Kigoriak**, Dome's first icebreaker. It has been joined by the **Father Robert LeMeur** (see cover photo).

The High Arctic

The sun, low on the High Arctic's horizon, highlights a Panarctic drill rig. *Photo: Panarctic Oils Ltd.*

Some 1200 kilometres northeast of the Beaufort Sea is an area known as the High Arctic. Bounded by Melville Island to the southwest and Ellesmere Island to the northeast, the geological feature underlying the island and the deep inter-island channels is called the Sverdrup Basin. In winter, the land of the High Arctic is scarcely distinguishable from the sea, and the permafrost extends to a depth of almost 1 kilometre. Few native people live in the region, and in the winter, the sun disappears below the southern horizon for months on end.

In this remote setting, Panarctic Oils has been searching for energy since 1966. Panarctic is an industry-government consortium owned 53 per cent by the Government of Canada (through Petro-Canada), and 47 per cent by a group of about 30 companies, including Dome, Home Oil, Norcen Resources, Bow Valley Resources, Cominco, Inco and Noranda Mines.

In the early 1960s, the Government of Canada made exploration permits available for the area between 72°N and 80°N, but no major oil company held permits long enough to proceed to the drilling stage.

Petroleum was plentiful at that time, so drilling that far north was not an attractive option. Then too, the dreadful climatic conditions of the area gave companies reason to hesitate. The waterways between the many islands are accessible by ice-reinforced ships, escorted by ice-breakers, for little more than one month of the year. The islands themselves are not much better: during the brief summer, from late August to early September, the top 30 centimetres of the land thaws and the resultant morass is all but impassable by wheeled vehicle.

In 1966, Panarctic was formed to meet this challenge. By 1969, the company had made a natural gas discovery at Drake Point on the Sabine Peninsula of Melville Island—almost 3000 kilometres north of Calgary.

Despite this land-based success, geological data indicate that most of the potential hydrocarbon area in the High Arctic is offshore. Unlike the Beaufort Sea, where 60 metres is considered to be deep water, the waters of Hazen Strait, Byam Martin Channel and other offshore areas of the Sverdrup Basin are up to 450 metres deep.

To tap this potential, Panarctic had to venture onto the ice-covered waterways to drill the ocean floor. But how to do it was a formidable problem. Drillships were out of the question because of the heavy ice cover, and artificial islands were unsuitable because of the great water depth. The solution was to use the ice itself as a drilling platform. It was a matter of boring through the ice and continuing down through the chilly water until contact was made with the ocean floor.

Putting this notion into practice was not easy, since the average thickness of the ice was insufficient to support a drilling rig, which weighs more than 1600 tonnes. The answer: drill through the ice with an ice auger; install a pump; flood the surface with several centimetres of sea water, which quickly freezes in the Arctic cold; and repeat this procedure day after day until the ice reaches a thickness of about 7 metres, enough to support a drill rig and associated equipment and crew accommodations.

Building Panarctic's ice platform is much like flooding a hockey rink. *Photo: Panarctic Oils Ltd.*

This freezing technique takes several months to complete: an obviously time-consuming and expensive proposition that takes crucial time away from the drilling period.

The reinforced ice platform technique has been used by Panarctic since 1974. The platforms are effective and (when you consider the alternatives) relatively inexpensive to construct. They are also, technologically, entirely Canadian.

In an attempt to solve the problem of thin ice covers, Panarctic freezes large urethane foam blocks into the thickening ice platform during construction. The foam blocks, because of their tendency to float, apply upward pressure that helps to support the massive drilling rig. This reduces the amount of ice needed to support the rig, and it also takes less time to complete the ice pad.

Reinforced ice platforms are well-suited to the conditions prevalent in the High Arctic. Unlike the Beaufort Sea, where the polar ice cap rotates constantly, the ice in the Canadian High Arctic is more or less locked in place by the surrounding islands. To the petroleum explorer, this means that once a rig is set up on the ice-island, it will not move very much relative to the ocean floor. Still, there is *some* movement, and to accommodate this the drilling "riser" has flexible "joints" to allow an offset within allowable limits of stress. The amount of horizontal motion can be as much as 5 per cent of the water depth, so the ice platform can shift 22.5 metres in water 450 metres deep.

A History of Searching

Alexander Mackenzie, who charted so much of Canada's West and Northwest, may have been the first white man to discover oil in the North. In 1789, while journeying up the river that much later was named after him, Mackenzie stopped at an embankment to examine a campsite. It was marked by slate formations (fine-grained, thin, smooth-surfaced layers of rock), where Indians gathered flint. Mackenzie noted in his journal that "petroleum-like pieces of yellow wax" were found among the small stones.

In 1887-88, Robert G. McConnell, a member of the Geological Survey of Canada, was exploring the Mackenzie Valley, along ground similar to that Mackenzie covered. He noted that the "possible oil country. . .is seen to be almost co-extensive with that of the valley itself." Then, as a portent of the 20th century, he wrote: "Its remoteness from the present centres of population . . . will probably delay its development for some years to come, but this is only a question of time."

Just three decades later, in 1920, oil was discovered at Norman Wells in the Northwest Territories — about 1450 kilometres northwest of Edmonton, not far from where Mackenzie had discovered his "yellow wax." By 1932, a small refinery at Norman Wells was supplying petroleum to markets along the Mackenzie Valley. Norman Wells is still in operation to this day, and a pipeline is being built to link it to southern markets. There is additional drilling being conducted along the Mackenzie River's shore and from islands in the river to gain access to the entire field. An increased flow of oil will also be achieved by injecting water into Norman Wells' reservoir.

The big finds in the Far North began in 1968 with the discovery of the major U.S. oil and gas field at Prudhoe Bay on the Alaskan North Slope, at the edge of the Beaufort Sea. A year later, nearly 200 million hectares off the Northwest Territories mainland, the Arctic Islands and offshore waters were let out under permit for oil and gas exploration. By 1979, this acreage had been reduced to about 73 million hectares as the companies sought the more promising areas, such as the Beaufort Sea - Mackenzie Delta region.

Norman Wells, on the Mackenzie River, has been active since 1932. Esso Resources will build artificial islands in the river in 1984 to tap the additional potential of the region.

To the Marketplace

As difficult as it is to discover oil and gas in Canada's North, an immense amount of work and investment will be required after commercial quantities of hydrocarbons have been found. The oil and gas must be brought out of the depths of the earth and transported to markets in southern Canada or elsewhere.

Several proposals (and they are only proposals at this point) for production and/or transportation systems have been developed. Many more are on the drawing board.

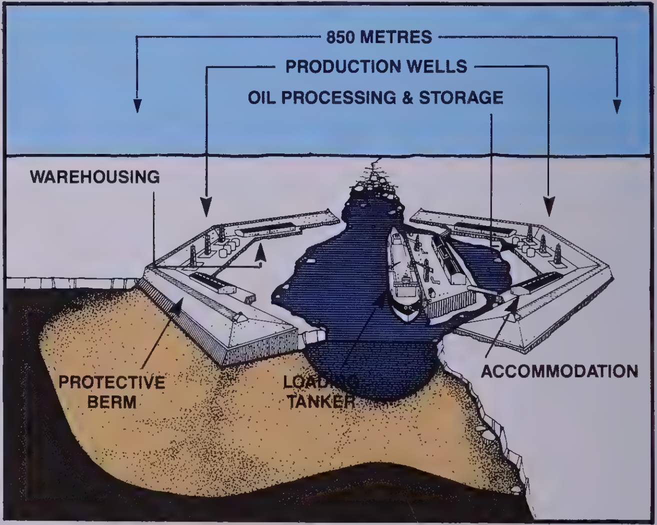
Production

One of the problems in frontier petroleum production is getting oil and gas to a collection point. With the exception of finds in the Mackenzie Delta or on the islands of the High Arctic, the discoveries are often in ice-covered water or open water menaced by ice floes and pack ice.

Dome, Esso and Gulf have developed a proposal that calls for the construction of offshore artificial harbours in the Beaufort—an extension of the caisson-retained island concept. Dubbed Arctic Production and Loading Atolls (APLAs), these artificial harbours would serve two purposes: to collect oil from a number of nearby subsea wellheads through a system of submarine pipelines; and to provide a mooring area for tankers that shelters them from ice and weather while they are being loaded with crude oil.

The APLAs would consist of two crescent-shaped artificial islands facing one another. Between the islands would be a body of water, or lagoon, about one kilometre in diameter, protected from ice, wind and waves. Tankers would be able to pass between the two crescents to enter the lagoon, and there would be sufficient space for them to maneuver once inside the harbour.

In the High Arctic, work has been done laying subsea pipelines to collect gas from seabed wellheads so that the output of a number of wells can be brought together at one collection point.



The proposed Arctic Production and Loading Atoll (APLA). Tankers will be able to make complete turns in such a man-made structure.

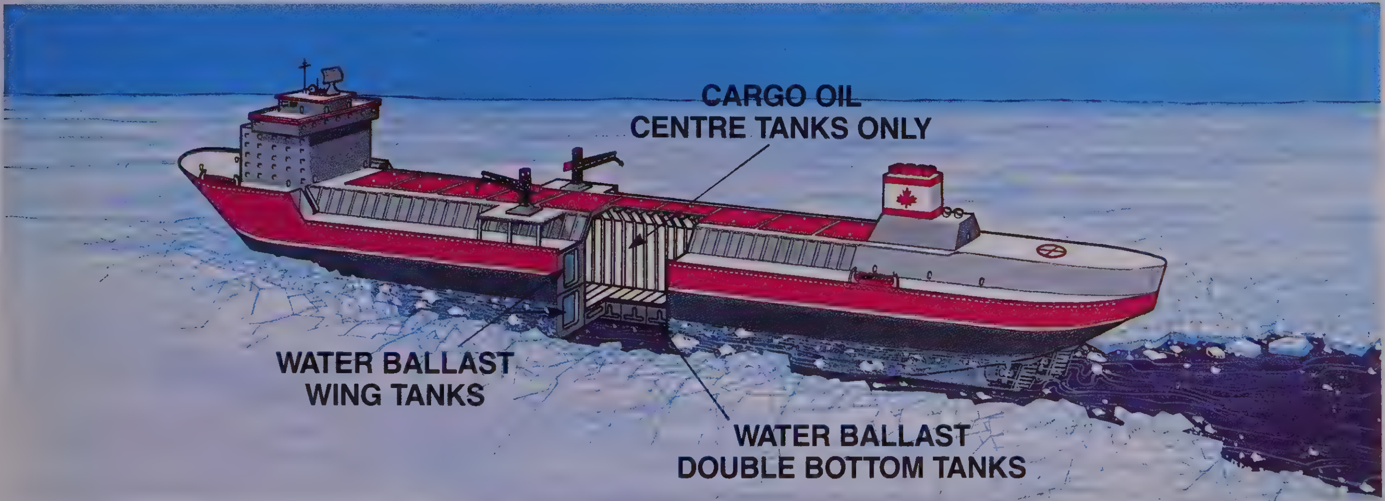
Transport — marine mode

A number of ice-breaking tanker proposals have been advanced that would see oil carried from the Beaufort or the High Arctic through the Northwest Passage to markets in eastern Canada. Such vessels would require very powerful engines and heavily reinforced hulls.

Natural gas can also be carried by tanker. When compressed and cooled, gas liquefies and can then be carried on ships equipped with special insulated tanks.

One such proposal involving liquefied natural gas (LNG) from the High Arctic is called the Arctic Pilot Project.

Gas from the Drake Point field on Melville Island would be brought by pipeline to Bridport Inlet on the south side of Melville Island. A liquefaction plant there would convert the gas to LNG, and it would be loaded aboard ice-breaking LNG carriers for shipment to market. On arrival at the end of its journey, the LNG would be converted back into a gas and fed into the normal pipeline distribution system.



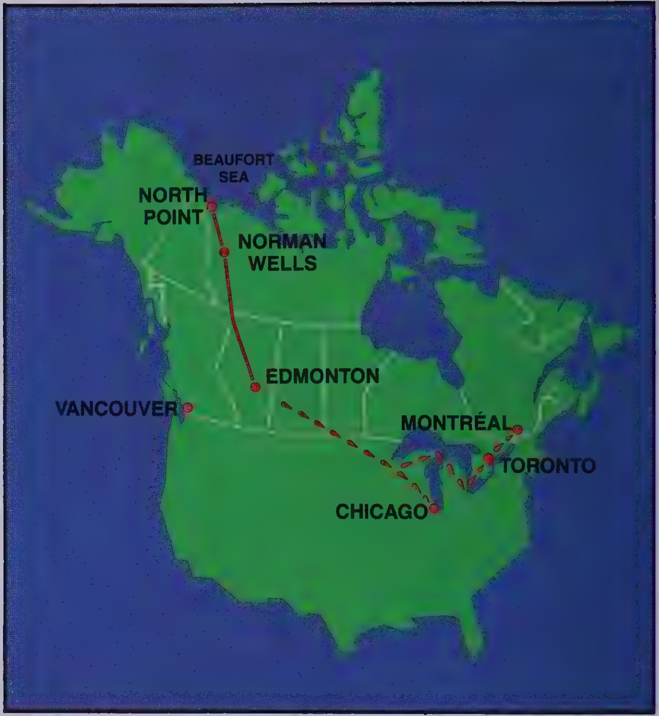
The proposed Arctic ice-breaking tanker, showing double-bottom tanks that minimize the risk of an oil spill.

Transport — pipeline mode

Both oil and gas move across Canada through a network of pipelines, bringing energy from the West to markets in eastern Canada.

In 1981, the Government of Canada approved the construction of an 870-kilometre oil pipeline that, when completed in 1985, will connect the oilfields at Norman Wells, Northwest Territories (located on the Mackenzie River west of Great Bear Lake) with the Canadian crude oil pipeline system at Zama, Alberta. Proposals are being developed that would link the Norman Wells pipeline with oil reserves in the Mackenzie Delta and Beaufort Sea by extending the pipeline a further 600 kilometres northwards.

Various proposals have been developed to use pipelines to move northern gas to market. The Polar Gas Project would collect gas from both the High Arctic and the Mackenzie Delta - Beaufort Sea with two "legs" that would meet just south of Coppermine, Northwest Territories. From there, the pipeline would run southeastwards to link with the existing natural gas pipeline network in northern Ontario. Other proposals for gas pipelines include a variety of routes along the Mackenzie Valley, as well as the Dempster Lateral route, which would connect gas reserves in the Beaufort Sea with the proposed Alaska Highway Gas Pipeline near Dawson, Yukon.



If a main pipeline is to be used to carry oil from the Beaufort Sea, it could be routed down the Mackenzie Valley and linked to the existing pipeline system at Edmonton.

Careful study

The collection and transportation proposals that have been developed must be evaluated carefully to ensure that such projects are consistent with environmental, socio-economic and safety standards and do not conflict with aboriginal rights. An extensive amount of scientific research must be done to ensure that such projects would not hamper traditional land use activities such as hunting and fishing — either in winter (on the ice) or in summer. Of particular concern is the issue of the effects of pipe-laying and of ice-breaking tankers on the populations of northern marine mammals, such as the seal, walrus and Beluga whale, in addition to sea birds and animals, such as polar bears, which spend much of their time on the sea-ice.

Wildlife found in the North. Clockwise: Arctic wolf; glaucous gull; thick-billed murre; muskox; and polar bear. *Photos: Parks Canada.*

Managing Resources Wisely

The Government of Canada is committed to the protection of the environment and the rights of native people in the North.

One of the legal instruments used to ensure this protection is the *Canada Oil and Gas Act*, which was passed into law in March 1982 to replace earlier (1961) legislation.

The Act provides for careful management and development of the immense petroleum potential in the North and in offshore regions. Oil and gas development cannot take place without respect for the environment or the interests of local residents.

Companies must provide detailed contingency plans outlining the response that will be made in the event of an accident. They must also guarantee prompt payment to correct any environmental damage, and make contributions to the Environmental Studies Revolving Fund, which finances approved environmental studies.

The Act requires that companies submit a Canada Benefits Plan prior to undertaking any work under an exploration agreement or development

Native peoples in the North are able to secure training and employment in petroleum-related industries.

plan. This ensures that Canadians are given full and fair access on a competitive basis to the industrial and employment benefits arising from exploration programs. Information must be given on the extent to which Canadian partners will be active in the exploration, and whether they will acquire the technical knowledge that will enable them, in time, to become Canada Lands operators in their own right.

The Act also states that any oil and gas resource activity in the North will not impair any existing land claims, whether they are concerned with the loss of traditional use and occupancy of land, or with claims encompassing the protection of fishing, hunting or trapping—or other rights and benefits.

There is legislative authority under the Act to establish special bodies to advise the Government on the development of oil and gas projects. These bodies would ensure that the interests of northerners are given full consideration.

In more immediate terms, the search for oil and gas in the North (in the Beaufort Sea - Mackenzie Delta area in particular), has already led to increased employment and purchasing power for native peoples. They continue to work at their traditional activities, such as winter trapping, but are also able to gain new skills—and increased disposable income—by working during the summer months in the oil and gas industry.

The new Act supports the Government of Canada's policy that native peoples, wherever possible, must be hired to work on resource development projects in their homeland.

To oversee and administer the new legislation, the Canada Oil and Gas Lands Administration (COGLA), was established under the *Canada Oil and Gas Act*, and is accountable to the Ministers of Indian Affairs and Northern Development and Energy, Mines and Resources.

COGLA's responsibilities include:

- Authorizing all proposed oil and gas activity, and establishing terms and conditions before industry proceeds;
- Insisting on regular inspections of all operations; and
- Requiring companies engaged in the search for oil and gas to undertake site-specific environmental studies and to submit detailed contingency plans that outline precisely the response which would be made in the event of a blowout or similar mishap.

Incentives and Benefits

To be self-sufficient in all forms of energy is a dream shared by the governments of almost every country in the world. Canada is one of the few industrialized nations that can realistically hope to achieve this goal.

The Government of Canada recognizes that the North contains some of our best prospects for large new petroleum finds. The Government has developed certain policies that make resource exploration in the North an attractive proposition for the oil and gas industry.

As is the case with any government having the responsibility for managing its national resources, the Government of Canada acts as a kind of landlord in permitting private companies to explore and develop resources within our boundaries. To ensure that all of Canada would benefit from the billions of dollars to be spent in the North, rules were established to encourage a high level of participation by Canadian workers and businesses.

Massive ice formations are monitored by trained professionals. Through exploration agreements, the Government of Canada ensures that as many Canadians as possible — particularly native Canadians — are employed in Northern exploration and development of oil and gas.

Through its exploration agreements with oil and gas companies, the Government ensures that exploration and development of oil and gas in the North employs as many Canadians as possible — particularly northern native people — and uses as many Canadian goods and services as is practical and feasible.

To encourage Canadians to participate financially in the costly quest for energy security, the federal government makes available generous cash incentive payments under the Petroleum Incentives Program (PIP). These payments apply across Canada and to all offshore regions. They are available to oil and gas companies and to individuals, and cover from 25 to 80 per cent of eligible expenses, depending on the degree of the company's Canadian content. The system also encourages joint ventures between Canadian- and foreign-owned companies.

There are a number of ways that individual Canadians may become involved and thus qualify for PIP payments. They may become shareholders in an oil and gas company, or purchase units in a drilling fund, or participate in an energy-related mutual fund. The amount of the payment will be determined by the amount of money invested in the project and the degree of Canadian ownership of the investing company.

Many Canadians, sometimes without being aware of it, participate in the search for frontier-region oil and gas. Pension funds and life insurance funds (to give only two examples) may be invested in energy-related projects. In addition, all Canadians participate as owners of Petro-Canada, and as part owners of Panarctic Oils Ltd.

Complementing the minimum 25 per cent PIP payment is the 25 per cent Crown interest in all rights issued to petroleum explorers in frontier regions. When a decision is made to proceed with petroleum development in Canada's North, the 25 per cent Crown share is converted into what is known as a working interest. This means that the people of Canada, through Petro-Canada or another designated Crown corporation, become active partners in the project, sharing the costs and benefits in bringing the petroleum from the North to the marketplace.

The Way Ahead

What do northern energy reserves, lying far beneath the frozen tundra or the ice-choked waters of the High Arctic, mean for Canadians? How can the cost and effort in finding these resources, bringing them into production, and moving them to Canadian markets, be justified?

The answers are simple: Canada's easily accessible oil and gas reserves are running out, and frontier resources will be needed to meet Canada's future needs. Despite significant efforts to conserve energy, Canada still needs petroleum products for transportation, heating, and industrial processes—the list is virtually endless. Every effort is being made even now to extract the greatest possible amount of oil and gas from the reserves in the Western Sedimentary Basin, which runs from northern British Columbia across to Manitoba. The tar sands and the West's sizable heavy oil deposits will provide other sources, but the petroleum that can be squeezed from these regions will ultimately slow to a trickle. Other sources must be found to replace the ones on which we now depend.

Resources from under the sea—principally off Canada's East Coast—will also play an important role; but again, at the cost of huge investments and technological challenges. (For more information on Canada's offshore resources, read *Energy Under The Sea*, available from Energy, Mines and Resources Canada, Communications Branch.)

So the challenge remains—to develop the North's energy resources in an environmentally and socially acceptable manner, so that oil and gas from Canada's Arctic can one day make a significant contribution to Canadian energy security.

Front cover The Dome Petroleum icebreaker **Father Robert LeMeur** clears a watery path for a drillship working in the Beaufort Sea. *Photo: Dome Petroleum Ltd.*

cover A drill rig in the High Arctic is swept by snow and wind. *Photo: Panarctic Oils Ltd.*

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Cat. No. M27-57/1983E
ISBN 0-662-12701-3

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